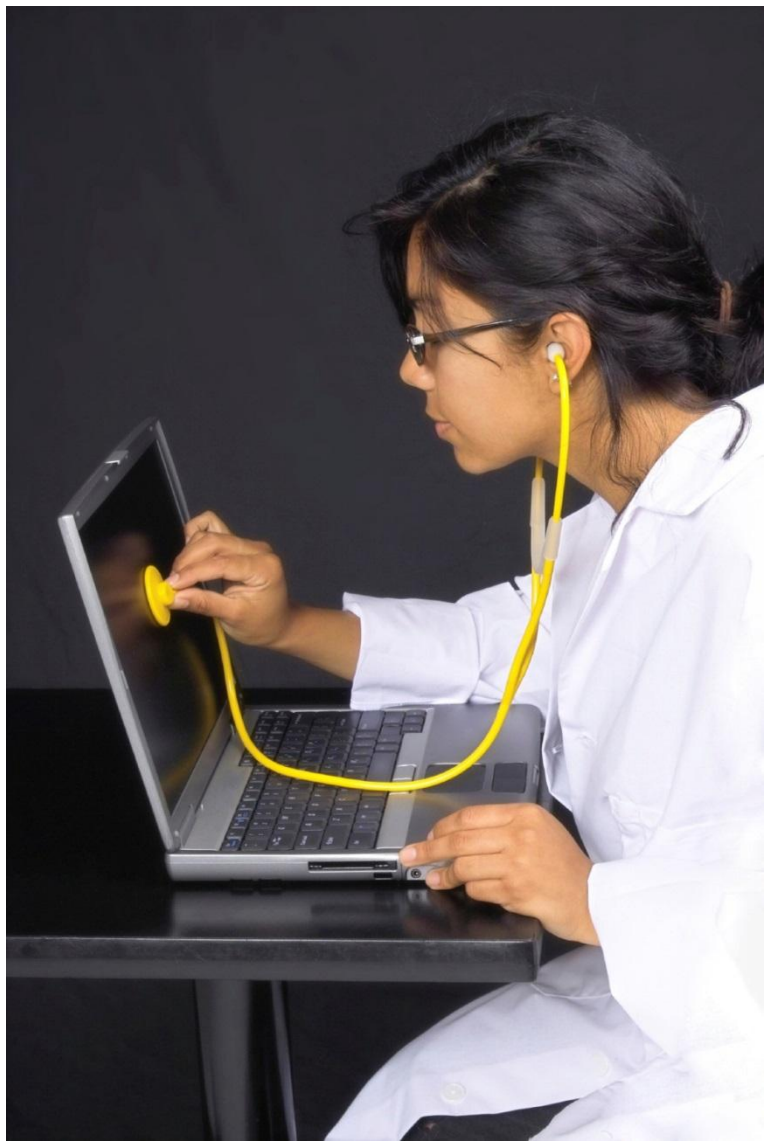






RINGS
Resource Circulation Initiative
for Next-Generation Sustainable Healthcare

No COI

Green Radiology in Japan: Recycling of Iodinated Contrast Media (ICM) and Gadolinium-based Contrast Agents (GBCA)

Diagnostic Radiology and Nuclear Medicine
Gunma University School of Medicine
Yoshito Tsushima, MD PhD

JSRS 2026.6.3

Green Radiology

Initiatives to Reduce Environmental Impact and Achieve Sustainable Medical Care in Diagnostic Radiology

- **Improving Energy Efficiency**
 - Introduce energy-efficient equipment and optimize operating hours. (MRI and CT consume large amounts of electricity)
 - Reduction of standby power. Utilization of clean energy.
 - Ensuring minimum power supply in the event of a disaster.
- **Appropriate use of contrast agents**
 - Consider the environmental impact of gadolinium and iodine contrast agents.
 - Minimal administration as necessary.
 - Use of alternative technologies (non-contrast MRI, AI-based image reconstruction, etc.)
- **Reduction of radiation exposure**
 - Reduction of unnecessary CT examinations and development of low-dose imaging techniques.
 - AI-based image analysis to improve diagnostic accuracy.
- **Waste reduction and recycling**
 - Appropriate disposal and recycling of contrast agents and electronic equipment.
 - Introduction of digital technology (electronic medical records such as PACS).
- **Reduction of carbon footprint**
 - Utilization of remote reading systems (teleradiology).
 - Reduce the need for travel.
 - Design of environmentally friendly medical facilities (energy efficient hospital design).

What is the problem?

ICM

GBCA

Environmental diffusion after use → Pollution?

Global shortage of raw materials

>90% of raw material supply is from China



Why not just collect and reuse them?

What is the problem?

ICM

GBCA

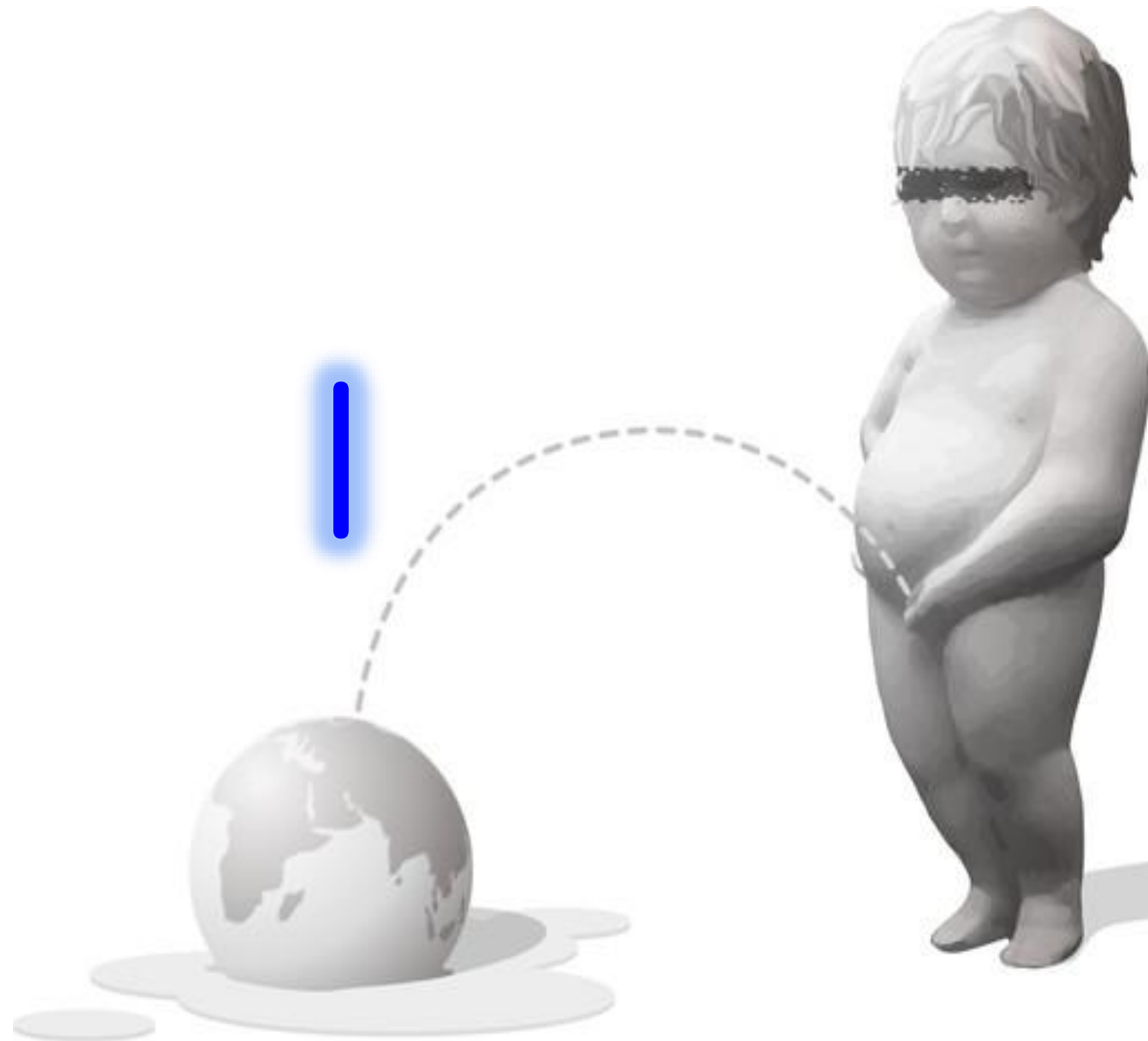
Environmental diffusion after use → Pollution?

Global shortage of raw materials

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Why not just collect and reuse them?



■ An estimated **80,000,000–120,000,000 doses/y** worldwide.

■ 10,000,000 L of ICM/y



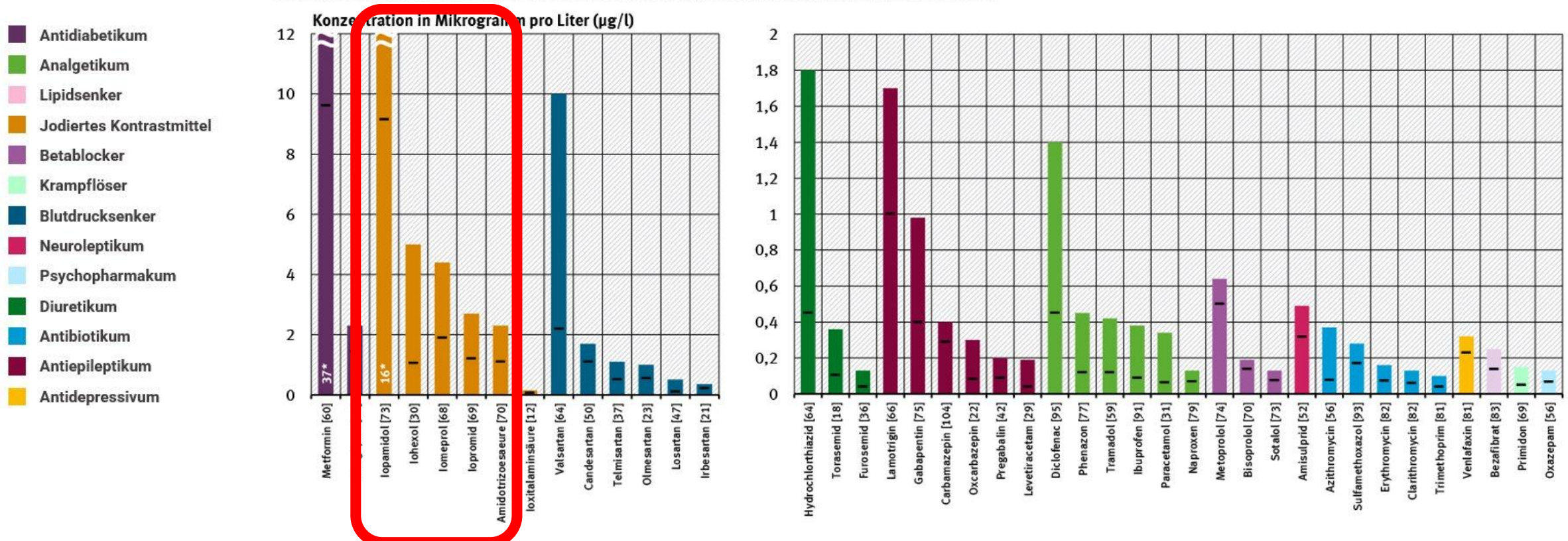
■ **3,500 ton of I/y**

Dekker HM, et al.
Insights Imaging. 2022

Pharmaceutical active ingredients detected in surface water at concentrations exceeding $0.1 \mu\text{g/L}$ (2021)

Arzneimittelwirkstoffe in Oberflächengewässern

Arzneimittelwirkstoffe, die 2021 in Konzentrationen über $0,1 \mu\text{g/L}$ in Oberflächengewässern gefunden wurden



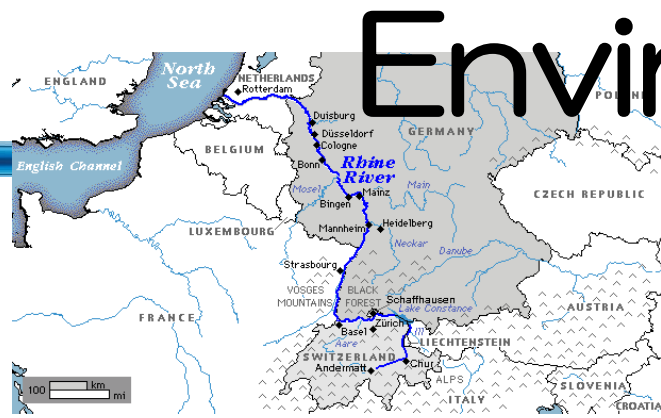
Säulen stellen die maximal gemessene Konzentration dar, Striche = höchster Jahresmittelwert aller Messstellen, Anzahl der Messstellen steht nach Stoffnamen in Klammern.

* Wert der maximal gemessenen Konzentration, da dieser außerhalb der Skala liegt.

Quelle: Zusammenstellung des Umweltbundesamtes (UBA) 2023 nach Daten der Bund/Länder Arbeitsgemeinschaft Wasser (LAWA)

Environmental diffusion of I

ICM



https://turtledove.fandom.com/wiki/Rhine_River

lekker HM, et al. Insights into Imaging 2022

Germany

Concentrations ICM in the Rhine River

ICM Load of the Rhine river:
■ 70kg/day
■ 71 ton/year

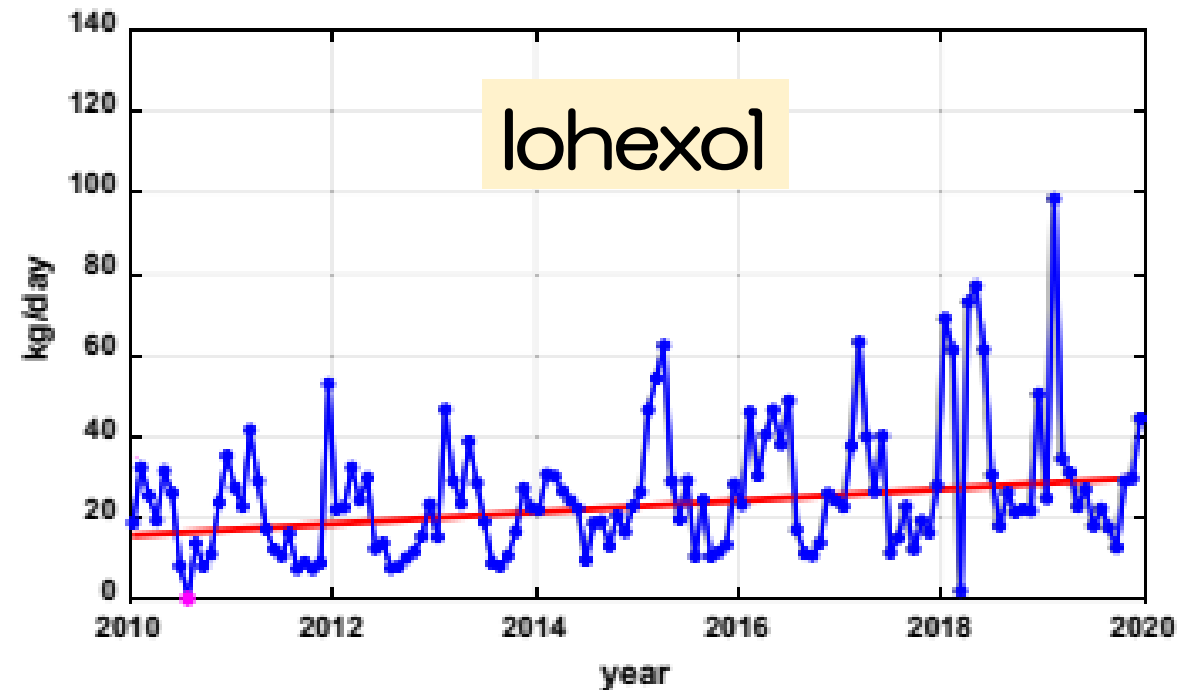
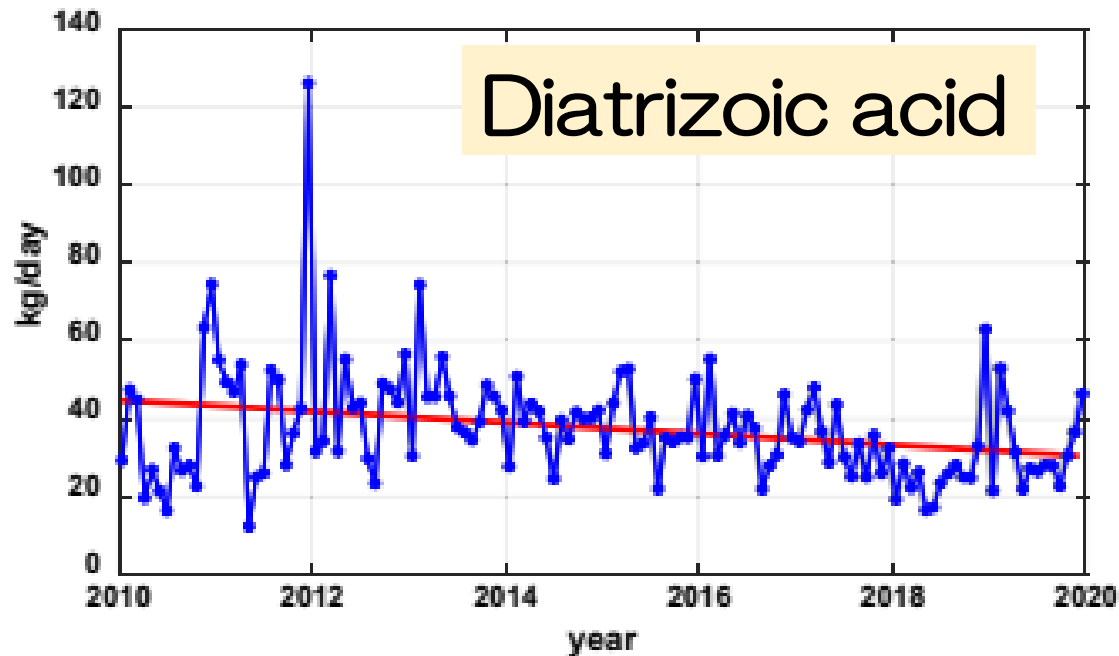


Fig. 1 Trends in the daily loads (kg/day) of Diatrizoic acid (left) and Iohexol (right) in the Rhine

Guermazi D, et al. J Neuroradiol 2024

Iodinated Disinfection Byproducts ヨウ素化消毒副生成物

I-DBPs

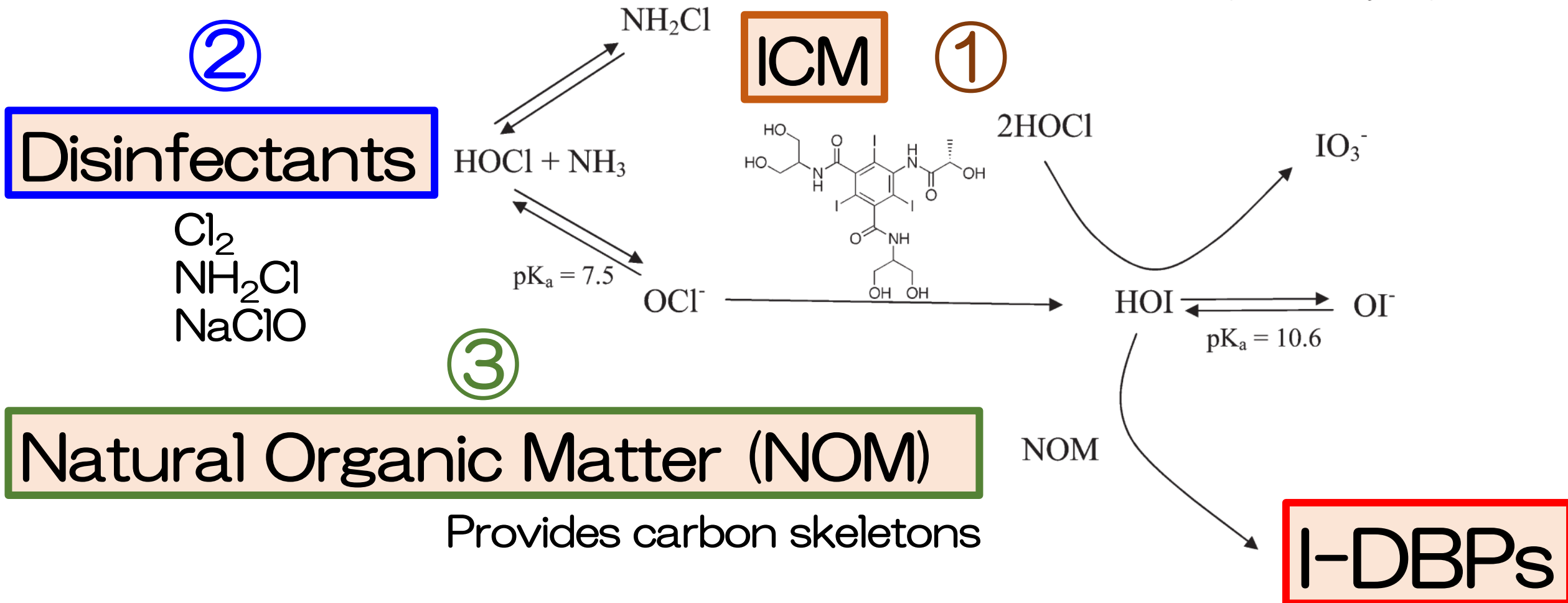
- ❑ A by-product produced when I reacts with organic matter in water during disinfection processes used in tap water and medical water treatment (such as chlorine disinfection, ozone disinfection, and chlorine dioxide disinfection) .
- ❑ Highly toxic?
- ❑ Affect water safety?

I-DBP production

Scheme 1. Proposed Pathway for Formation of Iodo-DBPs from Iopamidol

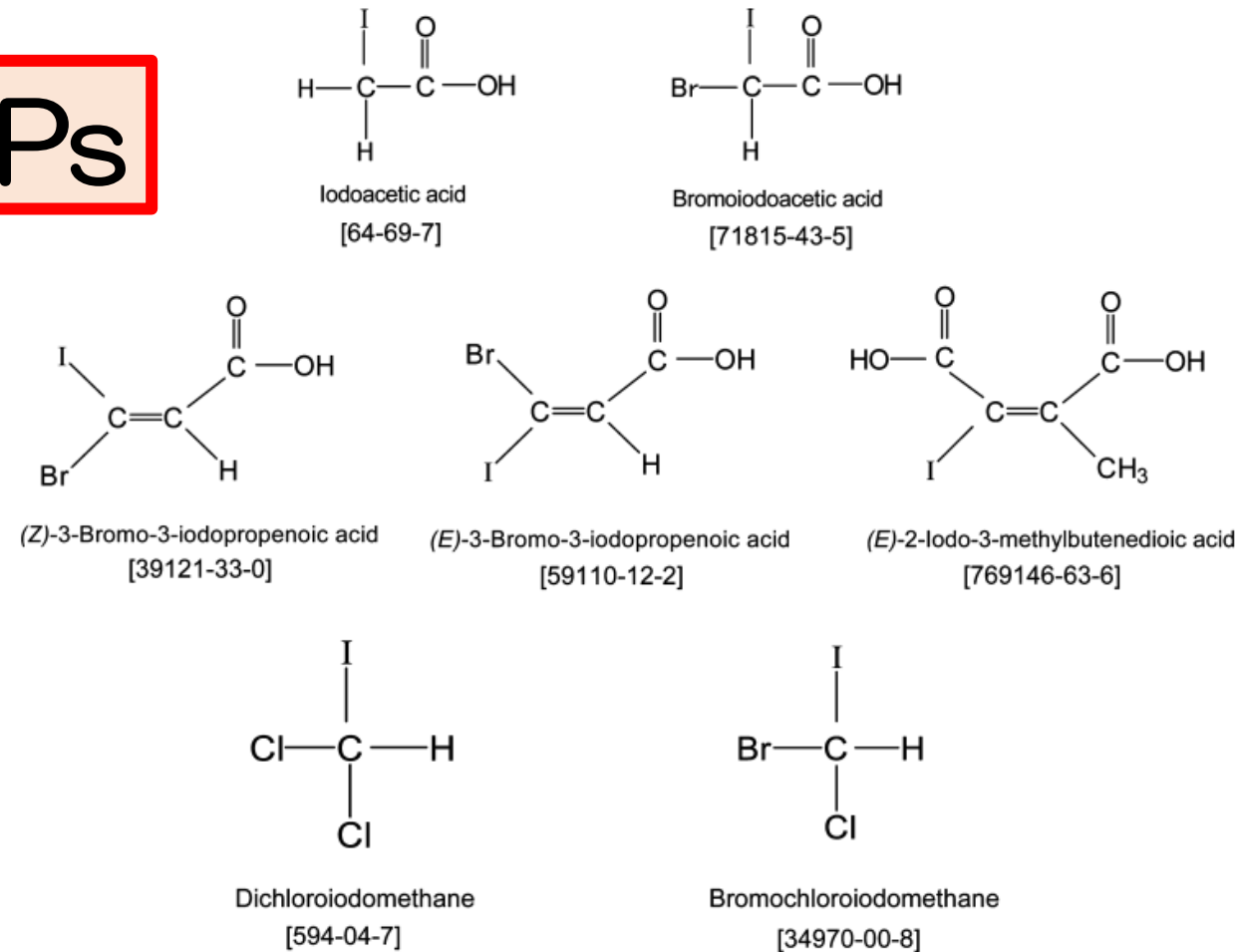
Formation of Toxic Iodinated Disinfection By-Products from Compounds Used in Medical Imaging

Stephen E. Dairk,^{†,‡} Cristal Lindell,^{†,‡} Christopher C. Cornelison,^{†,‡} Jennifer Kormos,[†] Thomas A. Ternes,[§] Matias Attene-Ramos,[§] Jennifer Osio,[§] Elizabeth D. Wagner,[§] Michael J. Plewa,[§] and Susan D. Richardson^{*,†}



I-DBP production

I-DBPs



Occurrence and Mammalian Cell Toxicity of Iodinated Disinfection Byproducts in Drinking Water

SUSAN D. RICHARDSON,^{*,†}
FRANCESCA FASANO,^{†,∇}
J. JACKSON ELLINGTON,[†]
F. GENE CRUMLEY,[†]
KATHERINE M. BUETTNER,[†]
JOHN J. EVANS,[†] BENJAMIN C. BLOUNT,[‡]
LALITH K. SILVA,[‡] TIM J. WAITE,[§]
GEORGE W. LUTHER,[§]
A. BRUCE MCKAGUE,^{||}
RICHARD J. MILTNER,[⊥]
ELIZABETH D. WAGNER,[#] AND
MICHAEL J. PLEWA[#]

Environ. Sci. Technol. **2008**, *42*, 8330–8338

① Cytotoxicity

- Cell death
- Inhibition of cell proliferation

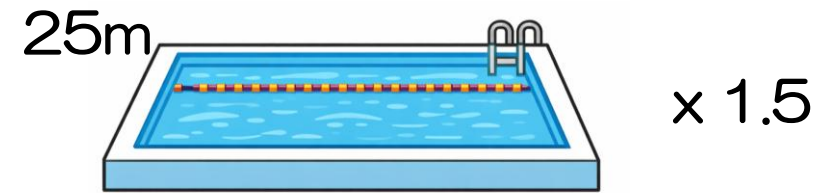
② Genotoxicity

- DNA damage
- Mutation induction
- Potential carcinogenic risk

FIGURE 1. Structures and CAS numbers of iodo-acids and iodo-THMs identified as DBPs in chloraminated drinking water and measured in this study.

Gd

- Since their introduction in 1988 more than 800 million GBCA doses have been administered worldwide.
- An estimated **63 million doses** in 2023.



■ 800,000 L of GBCA/y

■ **63 ton of Gd/y**
(0.5mmol/mL)

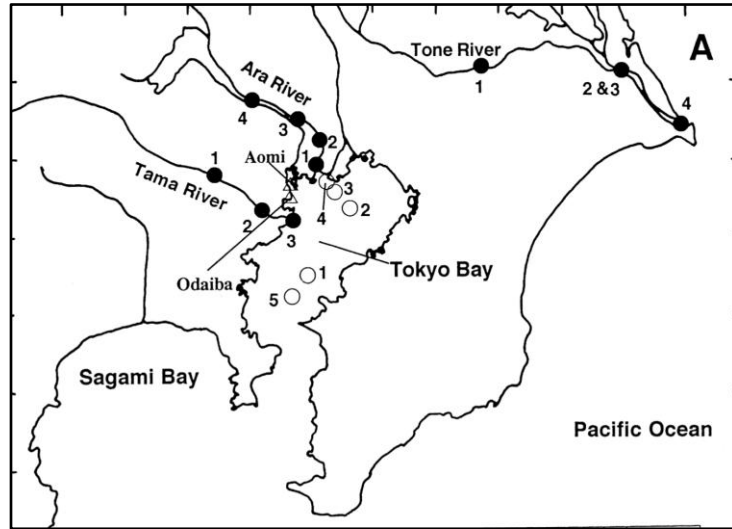
Environmental diffusion of Gd

GBCA

Nozaki Y, et al. Geo Cosmo Acta 2000

Kumasaka S, et al. Eur Radiol Exp. 2024

1996



Already 851%

2020



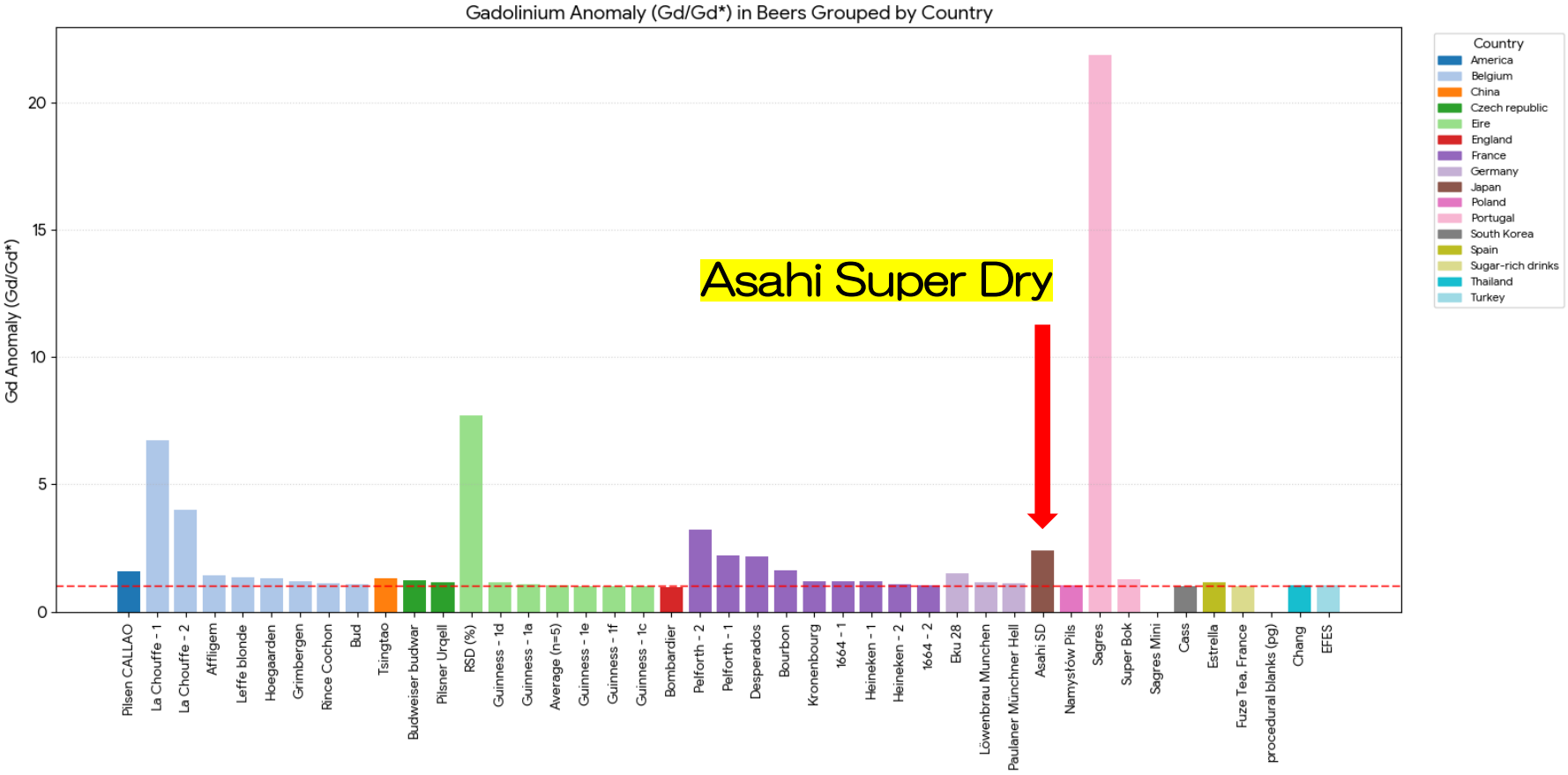
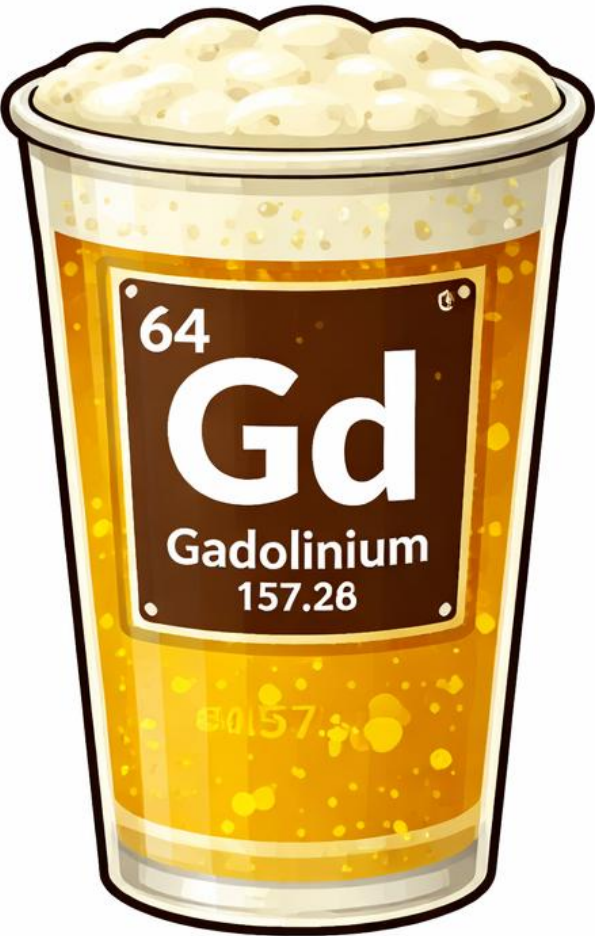
6,545% (max.)

7.7 times

Excess Gd in Beer

Food Chem 2025

2025



- ✓ Gd*: Theoretical value
- ✓ Gd/Gd*: If the value is 0, it can be interpreted that artificial excess Gd is not included.

What is the problem?

ICM

GBCA

Environmental diffusion after use → Pollution?

Global shortage of raw materials

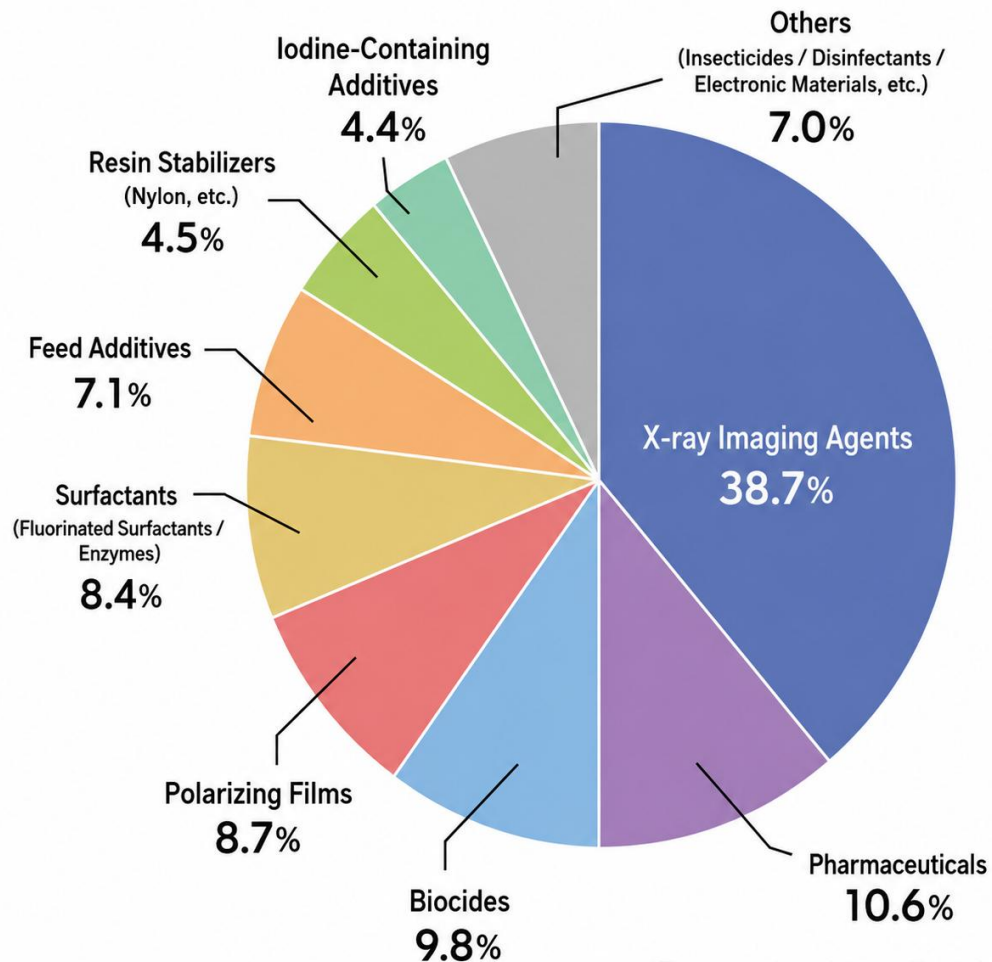
>90% of raw material supply is from China



Why not just collect and reuse them?

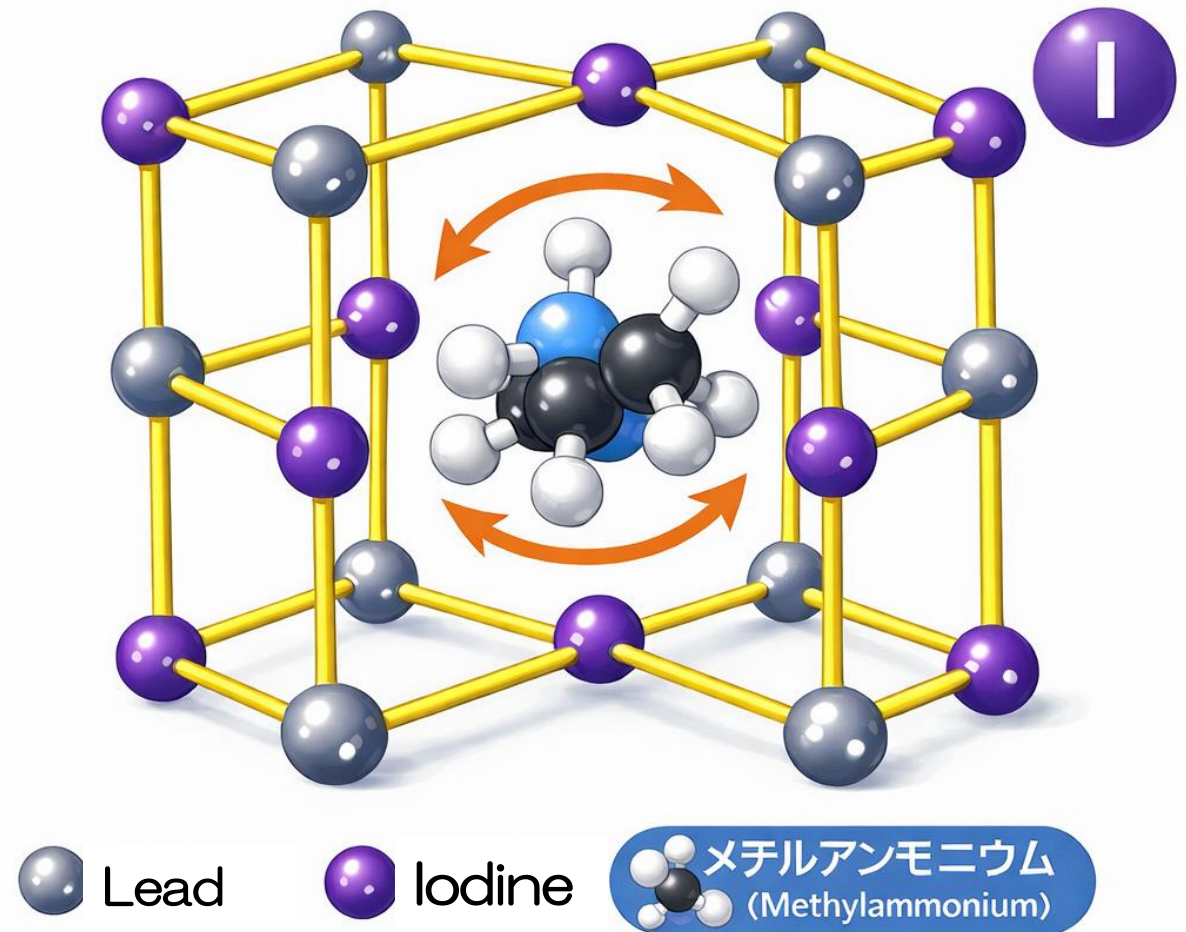
Uses and production of iodine

Uses of iodine



*Figures are based on weekly statistics.

Perovskite Solar Cells

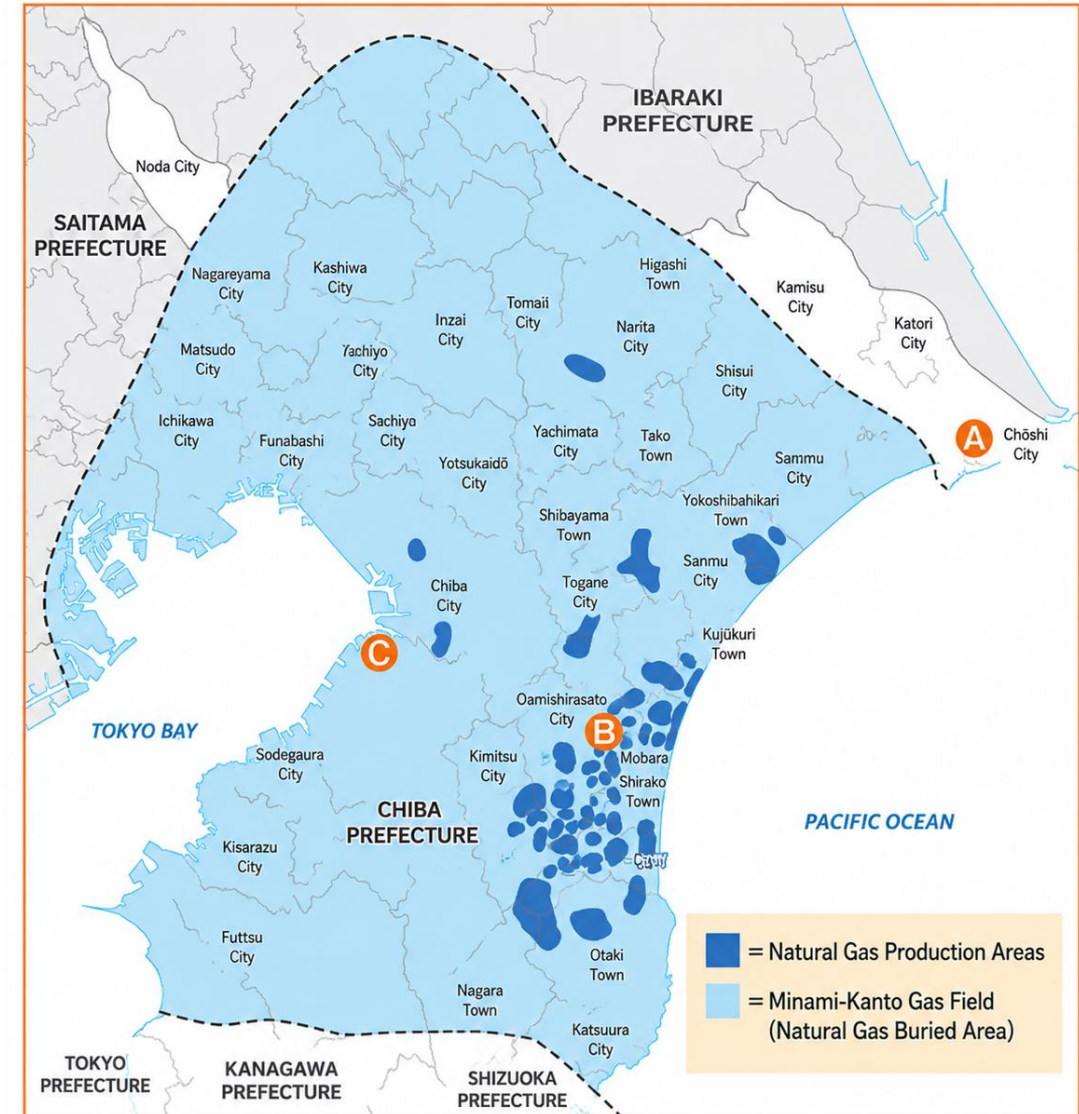


Uses and production of iodine

Iodine Producing Areas



▶ Natural Gas Fields in the Minami-Kanto Gas Field and the Chiba Area, Eastern Japan



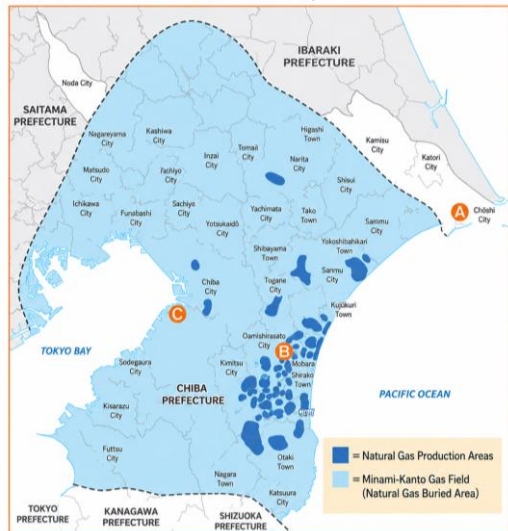
Production & recycling process of ICM

<https://www.godoshigen.co.jp/>

Many wells



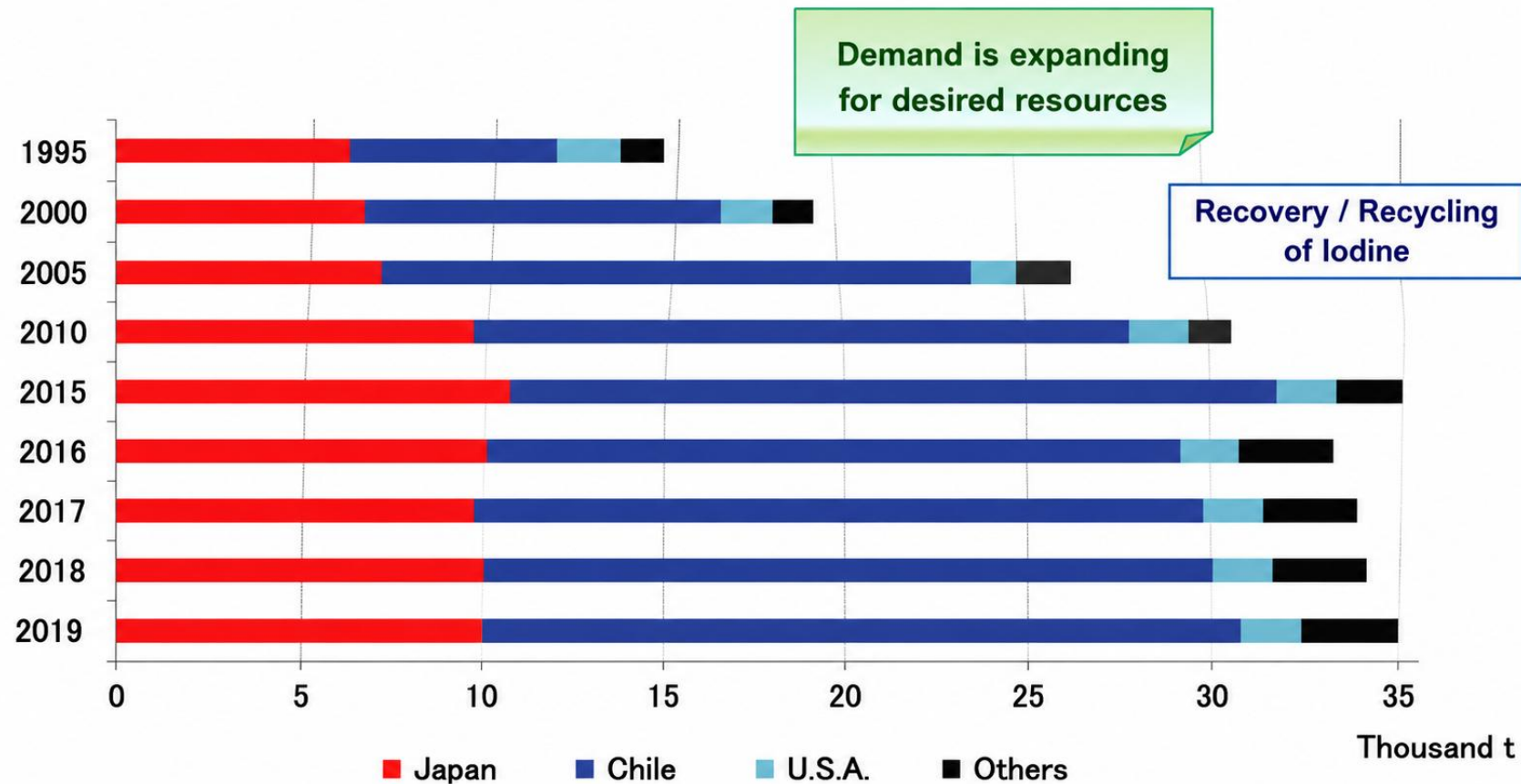
Final product



Uses and production of iodine

Iodine Production Volume

36,000 t/year



Currently, the growth rate is 2–3% per year

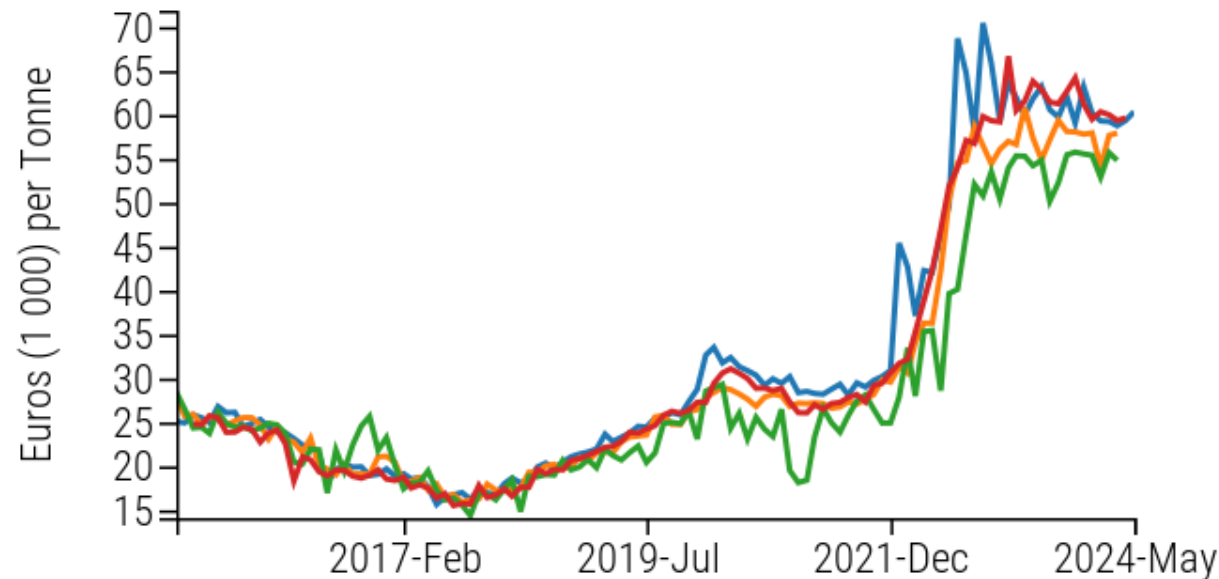
The sharp rise in iodine prices



Monthly Data, in Euros

- D - Last Price EU - Iodine
- D - History USA - Iodine - Import
- D - History USA - Iodine - Export
- D - History China - Iodine (China CIF)

Iodine Price Trends



https://www.pricepedia.it/en/magazine/article/2024/06/10/iodine-the-effects-of-a-high-concentration-of-world-supply/?utm_source=chatgpt.com

What is the problem?

ICM

GBCA

Environmental diffusion after use → Pollution?

Global shortage of raw materials

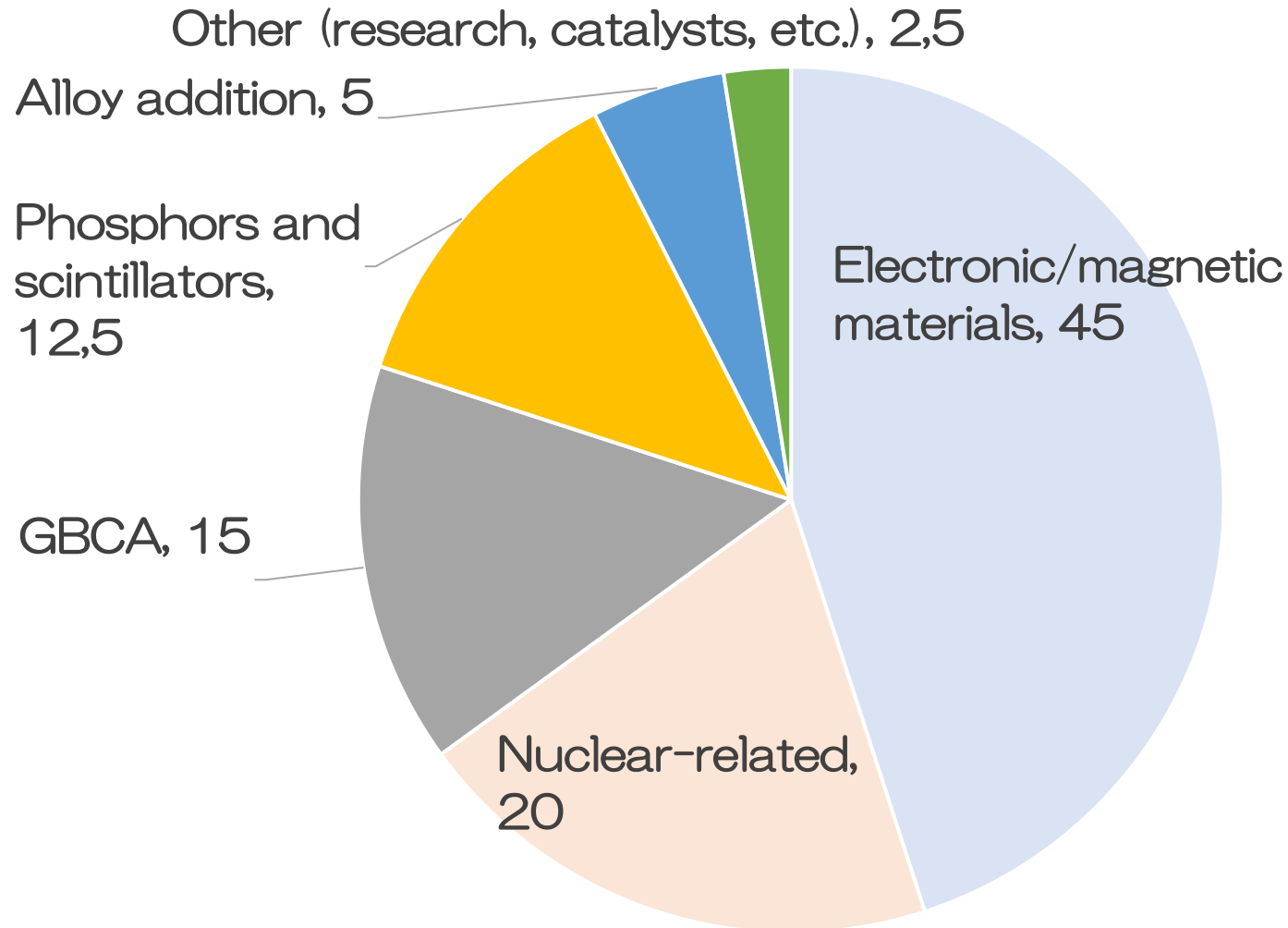
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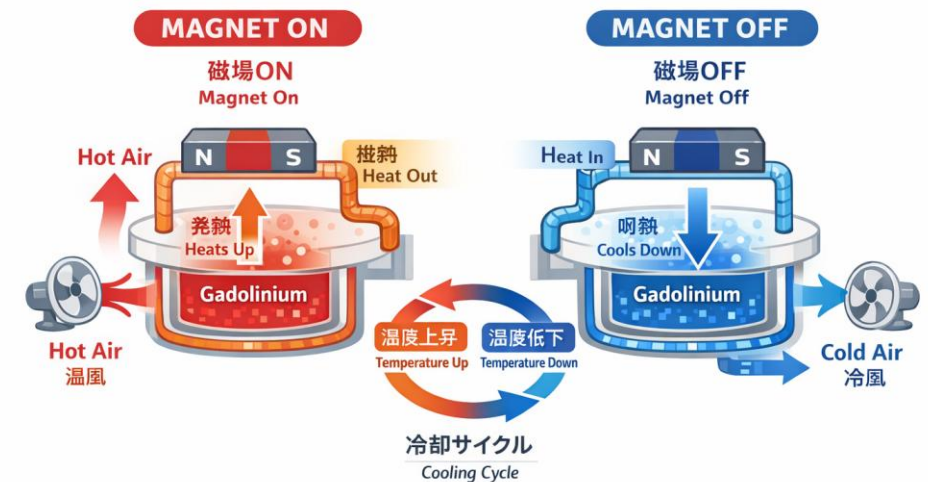
Why not just collect and reuse them?

Uses and production of gadolinium

Use of Gd



Magnetic refrigerator using gadolinium

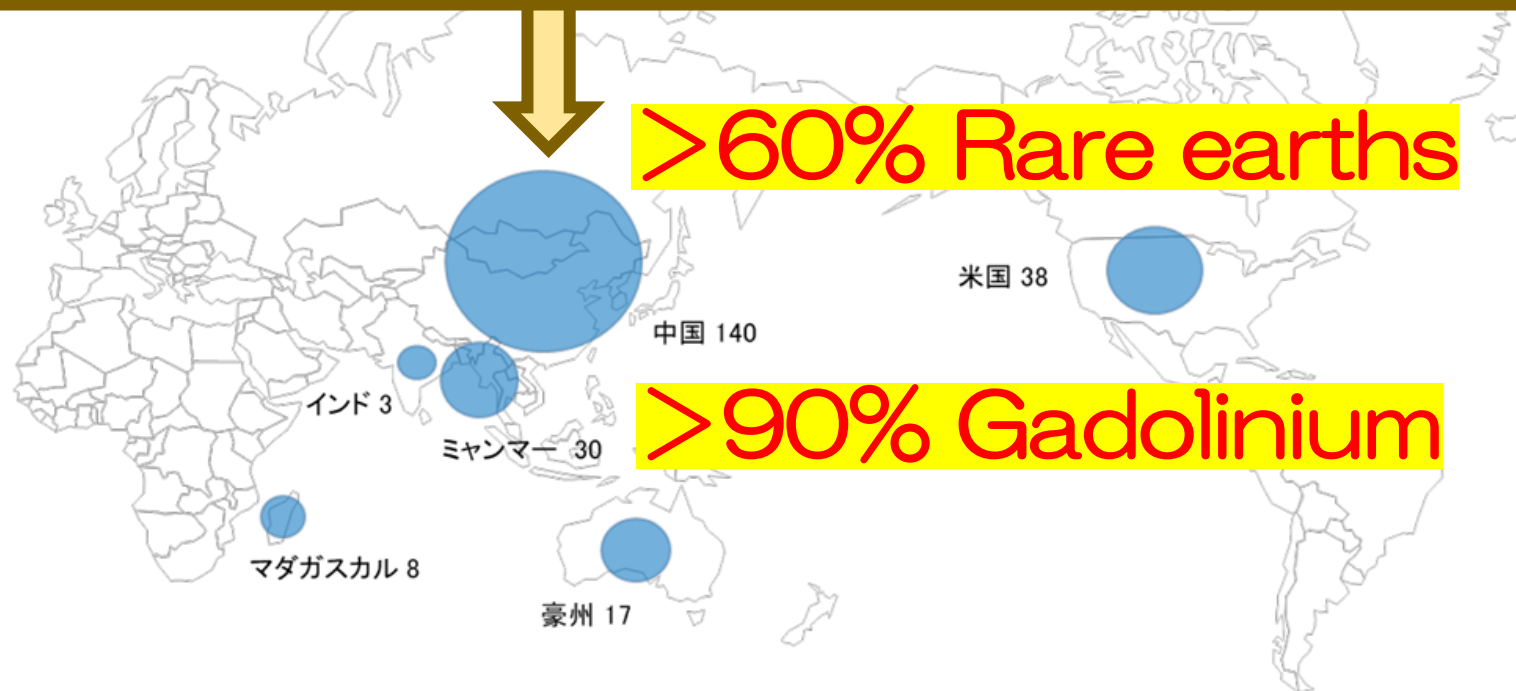


Unbalanced Gd production

GBCA

世界の産業を支える鉱物資源について知ろう

- The area is rich in easily extractable ores.
- Environmental regulations regarding the chemicals used in extraction are lax.



Unbalanced Gd production

GBCA



JOGMEC

独立行政法人 エネルギー・金属鉱物資源機構

鉱物資源マテリアルフロー 2018 8.レアアース (REE)



The Chinese government is reducing its rare earth export quotas.

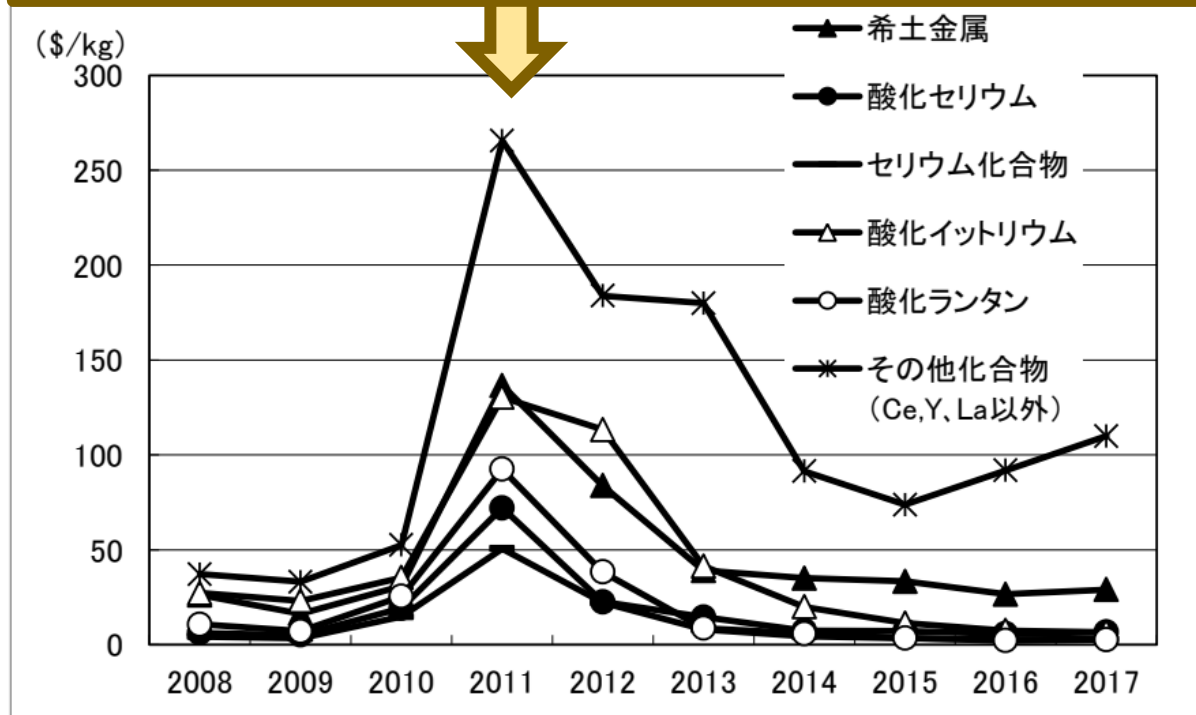


図 3-4 レアアースの平均輸入価格

What is the problem?

ICM

GBCA

Environmental diffusion after use → Pollution?

Global shortage of raw materials

>90% of raw material supply is from China



Why not just collect and reuse them?

Strategies to prevent I/Gd spread & Recycling

1. Recovery of contrast agent
 - 1) Patient urine
 - 2) Hospital wastewater
 - 3) Sewage treatment plant
 - 4) Residual liquid in syringe/tube

Industries



2. Changing the method of using contrast agents
 - 1) Optimizing the indications for examination
 - 2) Eliminating unnecessary CE examination
 - 3) Minimizing the dosage

Radiologists

3. Improvement of the contrast agent itself
 - 1) Adoption of contrast agents with a low amount of Gd
 - 2) Development of contrast agents that do not use Gd

Researchers

Strategies to prevent I/Gd spread & Recycling

1. Recovery of contrast agent

- 1) Patient urine
- 2) Hospital wastewater
- 3) Sewage treatment plant
- 4) Residual liquid in syringe/tube

Industries



Toilet Filtration System (TFS)

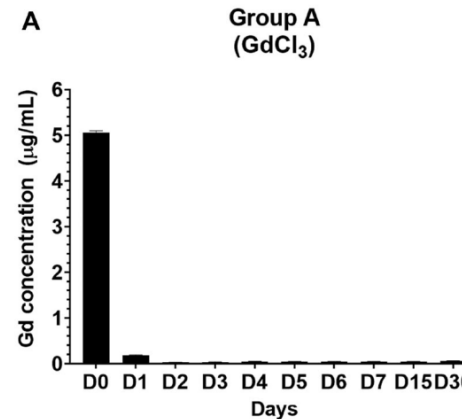
<https://megadore.org/>

Strategies to prevent I/Gd spread & Recycling

1. Recovery of contrast agent

- 1) Patient urine
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Industries



Toilet Filtration System (TFS)

<https://megadore.org/>

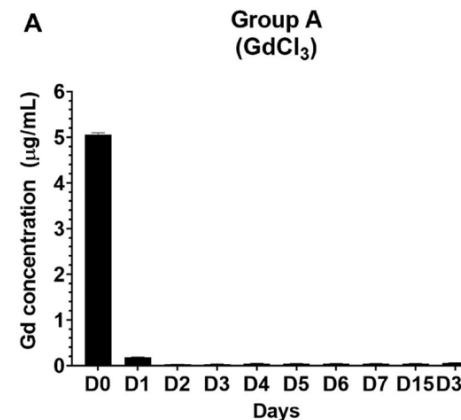
Kartamihardja AAP, et al.
Int J Phytoremediation 2022

Strategies to prevent I/Gd spread & Recycling

1. Recovery of contrast agent

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Industries



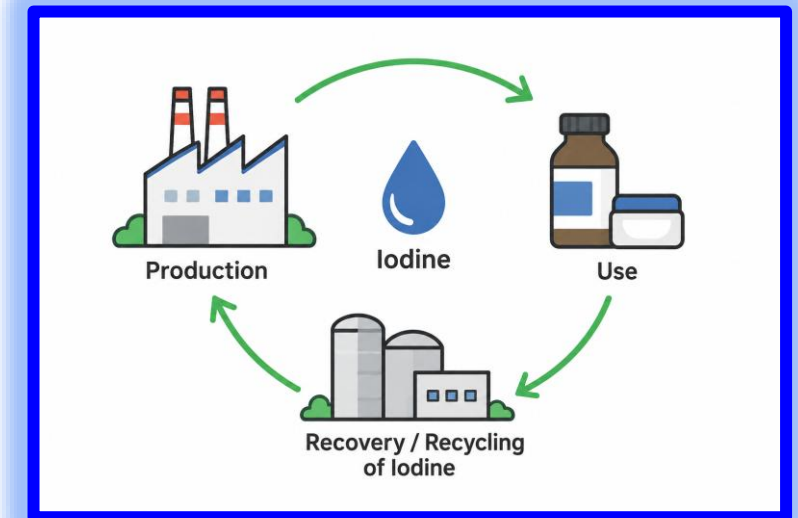
Don't flush it down
the drain!

Kartamihardja AAP, et al.
Int J Phytoremediation 2022



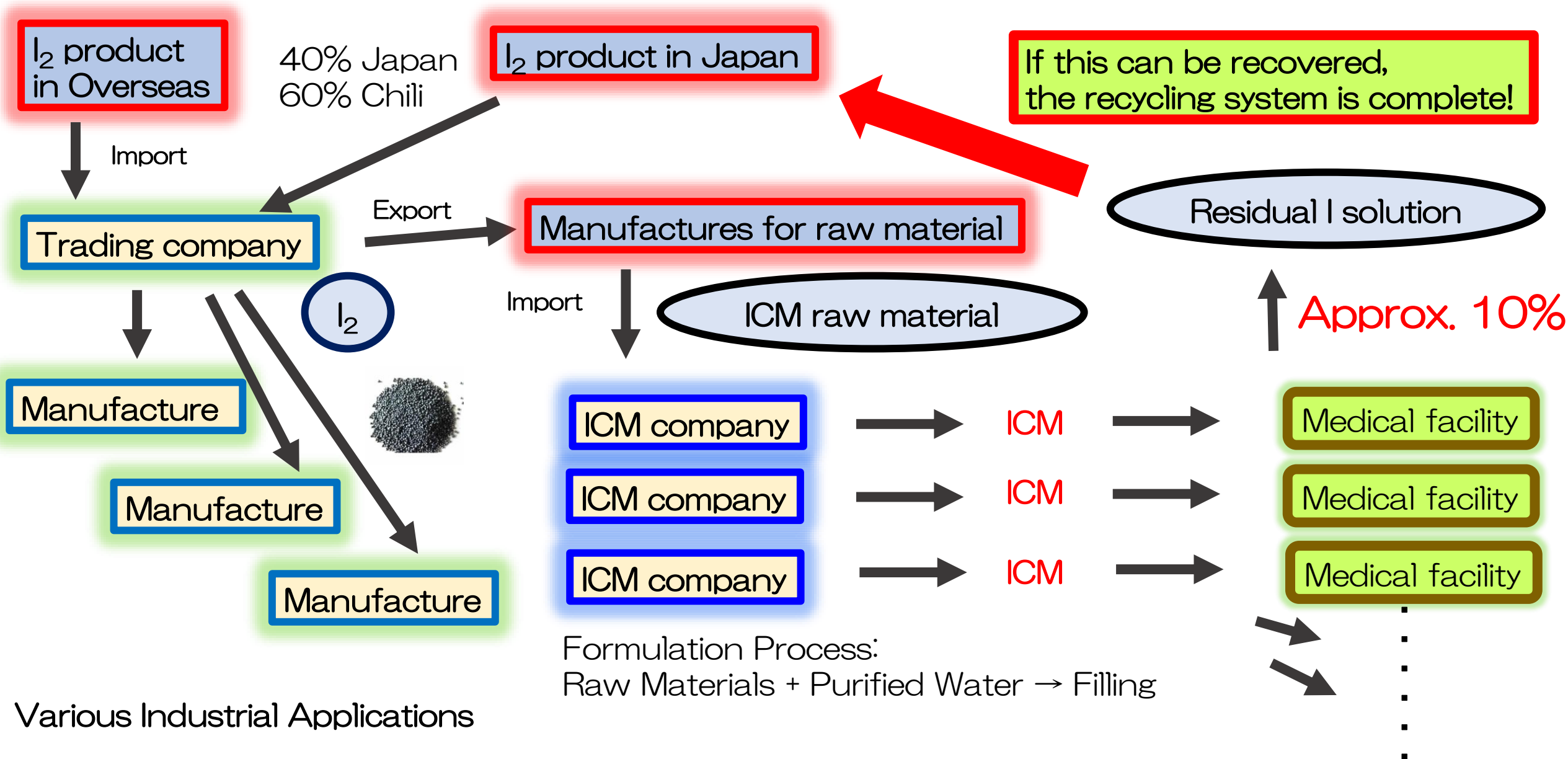
Toilet Filtration System (TFS)

<https://megadore.org/>



Production & recycling process of ICM

ICM



CT (Conventional Injector)



CT (Multi-use injector)



ICM

AG/IVR * 3



GBCA

MRI * 4



Production & recycling process of ICM

ICM

<https://www.godoshigen.co.jp/>

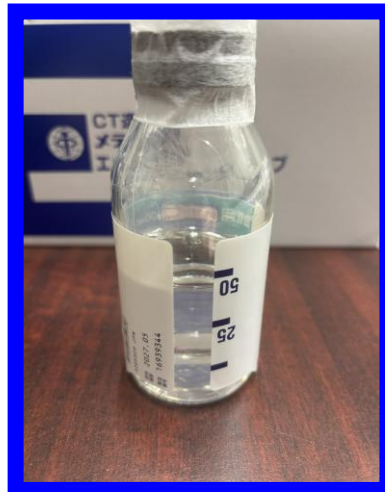
Many wells



800 °C



Final product



Residual
ICM

Strategies to prevent I/Gd spread & Recycling

2. Changing the method of using contrast agents

- 1) Optimizing the indications for examination
- 2) Eliminating unnecessary CE examination
- 3) Minimizing the dosage

Radiologists

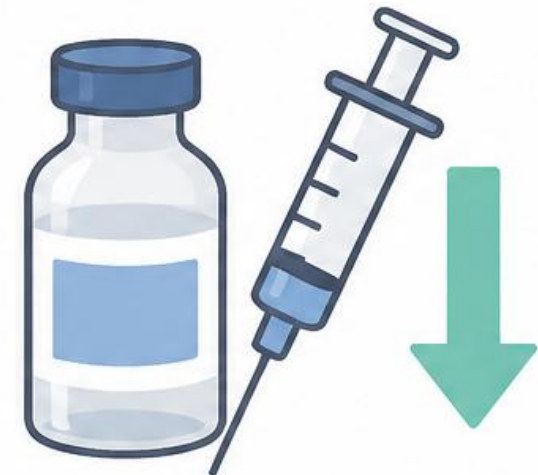
Optimizing the
indications for
examination



Eliminating
unnecessary CE
examination

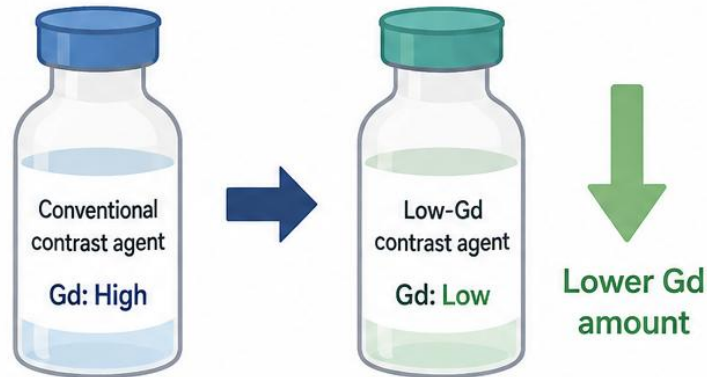


Minimizing
the dosage



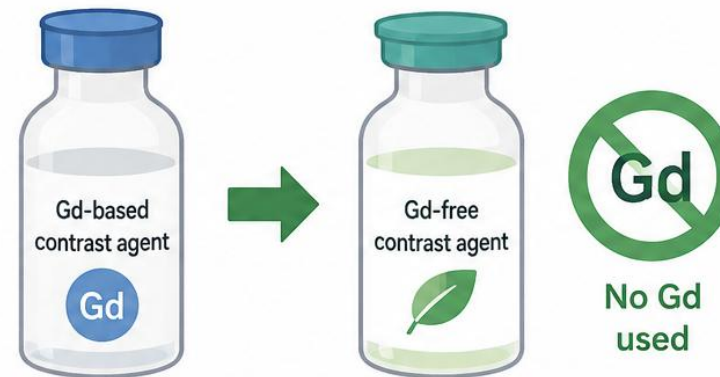
Strategies to prevent I/Gd spread & Recycling

1) Adoption of contrast agents with a low amount of Gd



Reduce the amount of Gd used while maintaining diagnostic performance.

2) Development of contrast agents that do not use Gd



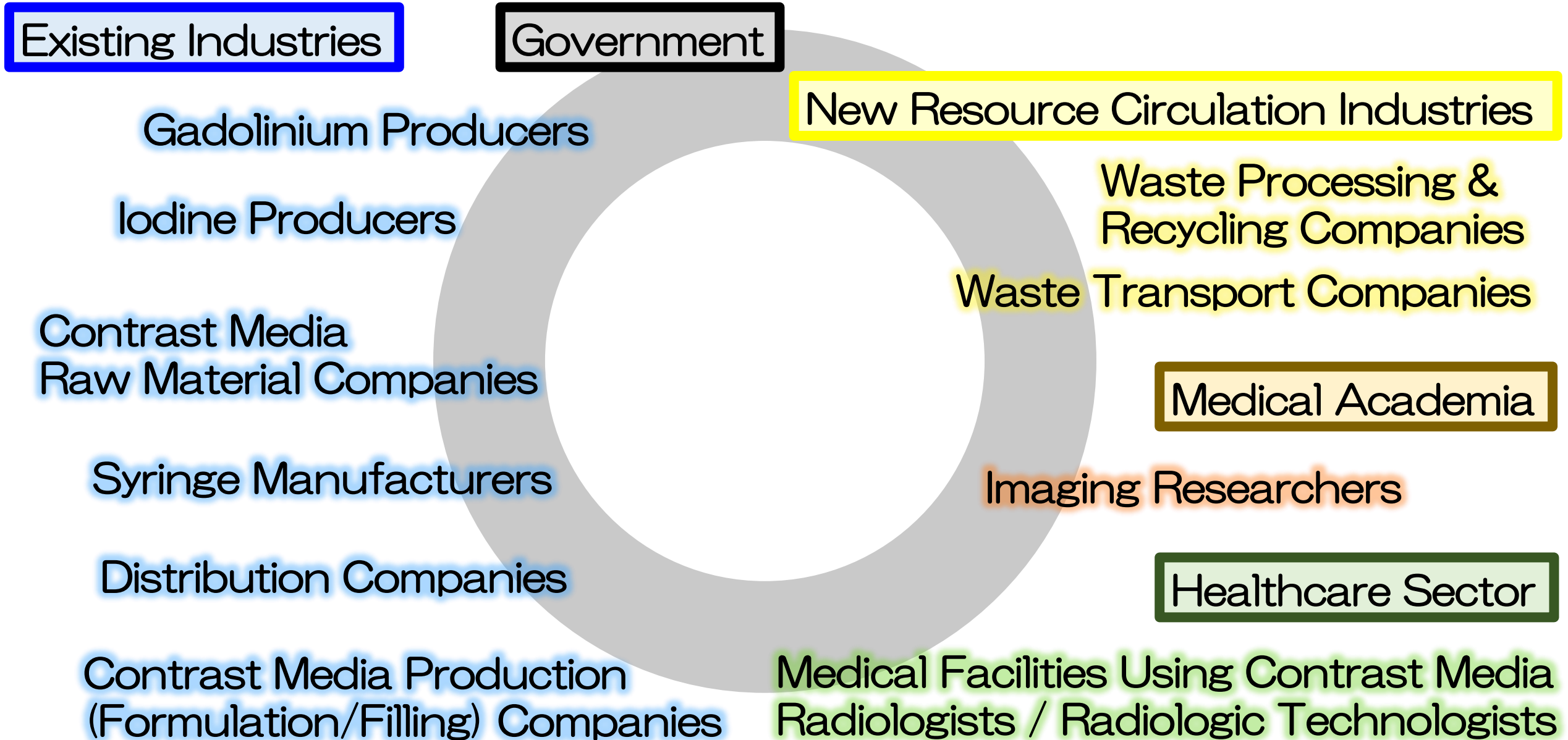
Realize high performance imaging without using Gd, contributing to safety and environmental protection.

3. Improvement of the contrast agent itself

- 1) Adoption of contrast agents with a low amount of Gd
- 2) Development of contrast agents that do not use Gd

Researchers

Stakeholders in Contrast Media Resource Circulation





<https://rings.med.gunma-u.ac.jp/>

